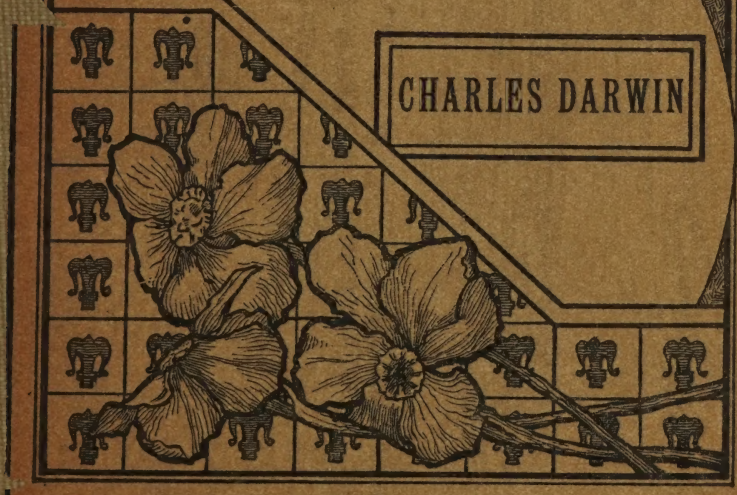
No. V.

The Round Table Series.

CHARLES DARWIN



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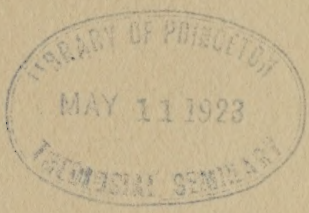
The Round Table Series



CHARLES DARWIN

NATURALIST

by
J. T. Cunningham

EDINBURGH: WILLIAM BROWN
26 PRINCES STREET
MDCCCLXXXVI

O RUGGED sage, strange confidant wert thou
Of Nature's choice to learn long secret lore,
Age-baffling riddles answerless before!
Ah, woman-like, she in the end must bow
To patience of pursuit, to constant vow,
To cunning study, yielding more and more,
To thy long siege, until the very core
Of her thought showed, invisible till now.

And thou art crowned with measureless acclaim
The greatest son of Science' brightest day,
To Newton's self at least co-equal fame:
Nay more, thou art a rock above the seas
Of superstition, and by thee the way
To a new church is given, and the keys!

MAN'S thought is like Antæus, and must be
Touched to the ground of Nature to regain
Fresh force, new impulse, else it would remain
Dead in the grip of strong Authority.
But, once thereon reset, 'tis like a tree,
Sap-swollen in spring-time: bonds may not restrain;
Nor weight repress; its rootlets rend in twain
Dead stones and walls and rocks resistlessly.

Thine then it was to touch dead thoughts to earth,
Till of old dreams sprang new philosophies,
From visions systems, and beneath thy spell
Swiftly uprose, like magic palaces,—
Thyself half-conscious only of thy worth—
Calm priest of a tremendous oracle!

Only 100 *of this Edition printed,*

of which this is No. 35 MS

CHARLES DARWIN.

AMONG the men who have endeavoured to establish a new or neglected theory, few have been rewarded by more rapid or more complete success than Charles Darwin in his efforts to obtain recognition for his views of the Origin of Species by means of Natural Selection. Few teachers have been regarded with such admiration by their disciples, or treated with so much respect by their opponents. No innovator has had less reason to complain of the indifference of his contemporaries. Round the "Origin of Species," was waged for years the keenest phase of the contest between the followers of science and the adherents of tradition. More than one generation of naturalists have drawn the inspiration of their best work from their enthusiasm for Darwinism. From Darwin's books evolutionary ideas have permeated into all streams of thought, until natural selection, and the struggle for existence are discerned in operation in all the manifestations of life. The theory of the evolution of living beings by gradual modification was not new. Buffon had suggested it as the necessary conclusion to be drawn from a review of the phenomena of the organic world. Dr. Erasmus Darwin had proclaimed it with a power and eloquence due too much to vividness of imagination, and too little to profundity of research.

Lamarck devoted the latter half of his life to advocating the truth of evolution, and of his views as to the causes of the process. In Britain, immediately before the publication of Darwin's arguments, Herbert Spencer had cogently urged the superiority of the hypothesis of evolution over that of special creation. Wells and Matthews had even reached the conception of natural selection. Yet the great majority of biologists were completely indifferent to these attempts to introduce a new leaven into the prevailing system of ideas concerning living beings. In spite of Buffon and Lamarck, Erasmus Darwin and Herbert Spencer, the greater number of naturalists still pursued their studies with the belief in the immutability of species as the background of their thoughts, and few conceived the possibility of treating as a scientific problem the question whether species were constant or plastic. One or two only, like Wallace, had reached conclusions similar to those of Darwin, and were prepared to support his arguments as soon as he produced them. But in a very short time after the appearance of the "Origin of Species," almost every naturalist of eminence had expressed his conviction of the truth of the conclusions expressed in that book. To Darwin clearly belongs the honour of having finally overthrown the dogma of the immutability of species, and so opened a broad path to the triumphant progress of biological researches. And it is also clear that the most successful weapon which Darwin wielded was the theory of natural selection. Although in many departments of biology it matters less what may be the cause of evolution than that the truth of descent with modification be apprehended, yet it is evident that the arguments of Herbert Spencer

would have had little effect on naturalists, and on men of average intelligence, who were nevertheless completely convinced by Darwin's theory of natural selection. So great and steadfast has been the allegiance of biologists in general to Darwin, that little attempt to criticise or develop his views was for a long time made by those who accepted the truth of organic evolution. Those who denied the modification of species altogether opposed Darwin energetically enough, but they fought against immensely superior forces. Some who were convinced of the truth of organic evolution, and were not personally familiar with biological studies, questioned the all-sufficiency of Darwin's explanation, but were usually met with the reply that only naturalists were competent to examine the question, and that naturalists were satisfied with the efficacy of natural selection. Only recently, now that the controversy between evolutionists and anti-evolutionists has subsided, has an impartial criticism of Darwin's position become possible, and the progressive development of the doctrine of organic evolution is now rapidly proceeding.

The mind's capacity for thinking about a phenomenon depends greatly on the ideas already acquired from those who have thought on it before. The possibility of the continuous modification of organisms had been suggested in a vague way before the time of Buffon; but it is obvious that Buffon received less assistance from predecessors than any of his successors received from him. The facts which most powerfully suggested to the great French naturalist the truth of organic evolution, were those of morphological relationship, of cultivation or domestication, and of

geographical distribution. The chief causes of modification, according to Buffon, are temperature and climate, the quality of food and the ills of slavery, by which last he means the conditions to which domesticated organisms are subjected by man. Buffon also drew attention to the selection exerted by man on domesticated animals as a means of perpetuating variations. But although he mentions the great tendency of organisms to increase in numbers, he draws no conclusion concerning natural selection by the struggle for existence. Erasmus Darwin was a disciple of Buffon. His arguments are based on the morphological relations of organisms, and the changes due to domestication; his idea of the cause of modification includes, besides the action of the environment, the effect of function, or, as Charles Darwin called it, use and disuse. Lamarck also was brought to his views by the morphological relations of organisms and the phenomena of domestication. Lamarck's idea of the cause of modification is as follows: the environment affects the habits of the animal, and the habits or functions affect the organs, and thus in the course of generations modifications of any extent are produced. Charles Darwin was early acquainted with the works of Buffon, Dr. Darwin and Lamarck, and thus his mind was ready as soon as his interest in living beings was excited, to consider their relation to the doctrine of evolution. At the same time it is evident that Darwin had more respect for the traditional and semi-religious belief in the immutability of species than he had for the earlier evolutionists.

In the 'Journal' he makes mention of Lamarck in discussing the blindness of the Brazilian Tucutuco. "Considering the strictly subterranean habits of the

Tucutuco, the blindness, though so common, cannot be a very serious evil; yet it appears strange that any animal should possess an organ frequently subject to be injured. Lamarck would have been delighted with this fact had he known it when speculating (probably with more truth than usual with him) on the gradually acquired blindness of the Aspalax, a gnawer living underground, and of the Proteus, a reptile living in dark caverns filled with water, in both of which animals the eye is in an almost rudimentary state. . . . No doubt Lamarck would have said that the Tucutuco is now passing into the state of the Aspalax and Proteus." Darwin himself in later years would have said much the same, only he would doubtless have sought to find how the Tucutuco derived some advantage, direct or indirect, from its imperfect vision. Yet his somewhat contemptuous parenthesis shows that at the period of his Journal he rejected altogether the general views of Lamarck, and when years afterwards he expounded his own theory of organic evolution in the "Origin of Species," he referred to the "erroneous views and grounds of opinion of Lamarck." But whatever the young naturalist thought of Lamarck's system, his remarks on the Tucutuco afford only one of the many evidences that his interest in the question of modification *versus* constancy in organic structure was thoroughly aroused during his years of travel. His celebrated chapter on the Galapagos Islands shows us that the probability of mutability in species was presented to him much more distinctly by the facts of distribution than by examples of imperfect adaptation to conditions. The islands are evidently geologically new, raised within a comparatively recent period above the surface of the ocean. Hardly any of

the species found in the Archipelago occur in any other part of the world, and there are many species which are confined to a single island. At the same time the species in almost all cases belong to American *genera.*

"It is probable that the islands of the Cape de Verd group resemble in their physical conditions far more closely the Galapagos Islands than these latter physically resemble the coast of America, yet the aboriginal inhabitants of the two groups are totally unlike, those of the Cape de Verd Islands bearing the impress of Africa as those of the Galapagos Archipelago are stamped with that of America." Another series of facts had also brought Darwin near to the problem of the origin of species, namely, the similarity between the fossil and living animals on the same continent. In America "there are fossil ant-eaters, armadilloes, tapirs, peccaries, guanacoes, opossums, and numerous South American gnawers, monkeys and other animals. This wonderful relationship in the same continent between the dead and the living will, I do not doubt, hereafter throw more light on the appearance of organic beings on our earth, and on their disappearance from it than any other class of facts." He mentions Buffon in this connection. "If Buffon had known of the gigantic sloth and armadillo-like animals, and of the later pachydermata, he might have said with a greater semblance of truth that the creative force in America had lost its power rather than that it had never possessed greater power." A little further on he shows that he had at the time of the publication of the Journal considered the subject of the struggle for existence :—"The supply of food on an average remains constant; yet the tendency in every animal to increase by propagation is geometrical, and

its surprising effects have nowhere been more astonishingly shown than in the case of the European animals run wild during the last few centuries in America."

But the greater proportion of his interest and energy was devoted during his voyage to the study of geology. His power and the bent of his mind were abundantly exhibited in this early work. He has the most masterly grasp of detail; but this faculty is treated not as an end in itself, but as a means of supporting some sweeping generalization, which explains and holds together all the separate phenomena. In the first paper he published after his return from his voyage, he unites all the results of his studies of volcanoes into a comprehensive view of their relation to the elevation of mountain chains. His great work on Coral Islands, published four years afterwards, traces all their features to the continuous subsidence of a portion of the earth's crust, in relation to the habits of coral polyps and the configuration of the portion of land gradually sinking below the sea. For ten years after his return to England, from 1836 to 1846, Darwin was almost entirely devoted to geology. Through these studies he became a firm believer in evolution as the true character of the history of the earth, and the immensity of time, which even small epochs of this history had occupied, was deeply impressed on his mind. We know from his own words that, in spite of his labours in geology, he had the problem of evolution in the world of living things continually in his thoughts. In his introduction to the "Origin of Species," we are told that though facts in the distribution of the organic beings in South America, and of the relation of the living to the fossil inhabitants of that continent, first led him to believe in the possibility of

the evolution of living beings through descent with modification, he was not satisfied with believing in the truth of the theory, and supporting it by the facts of embryology, geographical distribution, geological succession, and the analogy of domestic productions. What he required was a cause. Darwin had his own peculiar view of the nature of a cause. He sought some one universal principle which would explain all the details; at least he wanted to have some idea of how the divergence at present existing could have been produced. He rejected entirely, as we have seen, the views of Lamarck. In his letter to Hæckel explaining the course by which he reached his views, he says:—

"At an early period it seemed to me probable that allied species were descended from a common ancestor. But during several years I could not conceive how each form could have been modified so as to become so admirably adapted to its place in nature. I began, therefore, to study domesticated animals and cultivated plants, and after a time perceived that man's power of selecting and breeding from certain individuals was the most powerful of all means in the production of new races. Having attended to the habits of animals and their relations to the surrounding conditions, I was able to realize the severe struggle for existence to which all organisms are subjected; and my geological observations had allowed me to appreciate, to a certain extent, the duration of past geological periods. With my mind thus prepared, I fortunately happened to read Malthus's 'Essay on Population,' and the idea of natural selection through the struggle for existence at once occurred to me. Of all the subordinate points in the theory, the last which I understood was the cause of the tendency, in the descendants from a common progenitor, to diverge in character."

Darwin does not tell us at what period of his mental development he read Malthus. We know the date at which his first manuscript on the subject of natural selection was drawn up. This happened in the year 1839, and the essay was copied in 1844 when the copy

was read by Dr. Hooker, and communicated to Sir Charles Lyell. An extract from this manuscript was read before the Linnæan Society in 1858, and published in 1859. This extract develops Darwin's own personal view of the theory of natural selection, in the form in which he held it, with little if any modification, to the end of his life. In the following few sentences the central point of the theory is asserted.

"Now can it be doubted, from the struggle each individual has to obtain subsistence, that any minute variation in structure, habits, or instincts, adapting that individual better to the new conditions, would tell upon its vigour and health? In the struggle it would have a better chance of surviving; and those of its offspring which inherited the variation, be it ever so slight, would also have a better chance. Yearly more are bred than can survive; the smallest grain in the balance in the long run must tell on which death shall fall and which shall survive. Let this work of selection on the one hand and death on the other go on for a thousand generations, who will pretend to affirm that it would produce no effect, when we remember what in a few years Bakewell effected in cattle and Western in sheep, by this identical principle of selection."

In this published extract, as in all his expositions of his views, Darwin does not neglect the question of the origin of variations, but he does not go into it very elaborately. In the published extract, only half a paragraph deals with this question.

"Let the internal conditions of a country alter," he says, "if in a small degree, the relative proportions of the inhabitants will, in most cases, simply be slightly changed; but let the number of inhabitants be small, as on an island, and free access to it from other countries be circumscribed, and let the change of conditions be circumscribed (forming new stations), in such a case the original inhabitants must cease to be as perfectly adapted to the changed conditions as they were originally. It has been shown in a former part of this work that such changes of external conditions would, from their acting on the reproductive system, probably cause the

organization of those beings which were most affected to become, as under domestication, plastic."

Let us turn over the pages of the "Origin of Species," and see how the discussion of the problem is there elaborated. In the introduction it is pointed out that an unprejudiced naturalist, reflecting on various kinds of facts concerning organisms—such as their mutual affinities, by which is meant their morphological resemblances and differences; their embryological relations, the appearance, in the embryo, of structures which must once have been of use in a kind of life very different to that of the adult; their geographical distribution, as in the instance of the Galapagos Islands; and their geological succession, such as fossil sloths in South America, very different from the existing forms—might come to the conclusion that each species had not been independently created, but had descended like varieties from other species. Nevertheless, such a conclusion would be unsatisfactory, unless it could be shown *how* the innumerable species inhabiting this world have been modified so as to acquire that perfection of structure and co-adaptation which justly excites our admiration.

Naturalists continually refer to external conditions, such as climate, food, etc., as the only possible cause of variation. In one limited sense, this may be true; but it is preposterous to attribute to mere external conditions the structure, for instance, of the woodpecker, with its feet, tail, beak and tongue so admirably adapted to catch insects under the bark of trees. It is equally preposterous to account for the structure of the mistletoe, with its relation to several distinct organic beings, by the effects of external conditions, or of habit, or of the volition of

the plant itself. It is therefore of the highest importance to gain a clear insight into the means of modification and co-adaptation. To do this the author studies domesticated animals and cultivated plants.

First of all are considered the causes of variability, which, as we shall have occasion to suggest later, are as much in want of investigation now as when the "Origin of Species" was published. Cultivated organisms are more variable than those in nature: there is more difference between two individuals of a cultivated rose, than between two of the wild rose, and more difference between any two English race-horses than between any two zebras. The cause of this we are driven to conclude, is that the domesticated organisms have been raised under conditions of life not so uniform, and somewhat different from those to which the parent species had been exposed under nature. Some change is effected by the direct action of new conditions: that is, each generation, *as a whole*, not only some individuals, is changed from the parents in a certain direction. This is definite variability. The several breeds of the pigeon differ more than natural species from one another; yet it is almost certain that they are all descended from the rock-pigeon, *Columba livia*. But in the formation of all domesticated breeds the principal cause has been human selection; each breed possesses characters which in some special way serve man's wants or pleasures: and the breed has been produced by man, selecting in each generation among the varying individuals those in which such characters were present in the greatest degree.

The next question is, do variations occur in a state of nature; and the answer is that no two individuals of

a given species are exactly alike. Any naturalist who examines a number of specimens of one species finds in some the "specific characters" all well marked, in others all of them less pronounced, while in others some are distinct, others less prominent. In many species there exist *varieties* which only differ from *species* in diverging in a less degree from the species to which they belong, and by being united to them by intermediate links in which the characters of the variety and the species are blended.

But the mere existence of individual variability, and of some few well-marked varieties is not sufficient to account for the exquisite adaptions of one part of the organization to another part, and to the conditions of life. Nor does it explain how varieties become converted into distinct species, and how the groups of species known as *genera* arise. These results follow from the struggle for life. Owing to this struggle, variations, however slight and from whatever cause proceeding, if they be in any degree profitable to the individuals of a species, in their infinitely complex relations to other organic beings, and to their physical conditions of life, will tend to the preservation of such individuals, and will generally be inherited by the offspring. This is the principle of Natural Selection, called by Herbert Spencer, "the survival of the fittest." Darwin points out that the term, "struggle for existence," is used in a large and metaphorical sense. The struggle inevitably follows from the high rate at which all organic beings tend to increase, while the actual numbers of a given species never increase so fast, often decrease, and sometimes remain stationary. There is no exception to the rule that every organic being naturally increases at so high a rate, that,

if not destroyed, the earth would soon be covered by the progeny of a single pair. Even slow-breeding man has doubled in twenty-five years, and at this rate in less than a thousand years there would literally not be standing room for his progeny. There is direct evidence of the high rate of increase in numerous instances. The cattle and horses introduced into South America, and latterly into Australia, have multiplied to an enormous extent, and this not because the rate of breeding has increased, but because the conditions were favourable, principally because suitable food was abundant. The exact nature of the checks to increase, of the conditions which limit the population of a given species, is obscure. The amount of food gives the extreme limit, but very frequently it is more the danger from enemies in the shape of other organisms which restricts the numbers. The complex relations in which animals and plants stand to one another when the subject is examined are seen to be marvellous. The celebrated instance given by Darwin may here be quoted :—Red clover, Trifolium protense, can only be fertilized by humble bees. The number of humble bees depends in great measure on the number of field-mice, which destroy their combs and nests, and the number of field-mice is largely dependent on the number of cats.

Carl Vogt has pursued this chain of argument a little further. "As the red clover is one of the most important and best foods for the bullock, its quantity and quality influences the quantity and quality of beef, which is well known to be indispensable for the proper nourishment of the British nation. As further the most highly developed functions of this nation, its industry, marine, free institutions depend on the strong

development of the brains of Britons, which again depends on the abundant nourishment of these brains with beef, we find that the number of cats in England has ultimately a profound influence on the whole perfection of culture, which at the present time places Britain in many respects at the head of all nations."

The most difficult thing to understand, according to Darwin, is how divergence of character is produced, or when produced tends to increase. The explanation is that the greatest amount of life can be supported by greatest diversification of structure. A carnivorous quadruped can only succeed in increasing by its varying descendants seizing on places at present occupied by other animals, some inhabiting new stations, climbing trees, frequenting water, and some perhaps becoming less carnivorous.

By natural selection, each creature tends to become more and more improved in relation to its conditions, and then Darwin goes on to say this improvement inevitably leads to the gradual advancement of the organization of the greater number of living beings throughout the world. If we take as the standard of high organization, the amount of differentiation and specialization of the several organs in each being when adult natural selection clearly leads towards this standard; for all physiologists admit that the specialization of organs is an advantage to each being. But it is quite possible for natural selection gradually to fit a being to a situation in which several organs would be superfluous or useless.

The next chapter discusses the laws of variation, which are generalizations based on a survey of facts, though the actual causes of variation are not very

evident. Use and disuse of parts have caused the greater development or the reduction of these parts. Homologous parts tend to vary in the same manner, and when adjacent, tend to cohere. Organic beings low in the scale are more variable than those standing higher. Rudimentary organs are variable.

The existence of lowly organized forms is briefly discussed :—

"In some cases lowly organized forms appear to have been preserved to the present day from inhabiting confined or peculiar stations, where they have been subjected to less severe competition, and where their scanty numbers have retarded the chance of favourable variations arising. In some cases, variations or individual differences of a favourable nature may never have arisen for natural selection to act on and accumulate. In some few cases there has been what we must call retrogression of organization. But the main cause lies in the fact that under very simple conditions of life, a high organization would be of no service—possibly would be of actual disservice, as being of a more delicate nature and more liable to be put out of order and injured."

The difficulties of the theory are frankly considered. The chief of these are the absence of transitions, the existence of instincts and organs of extreme complexity, and the fact that species when crossed are either sterile or produce sterile offspring, whereas varieties when crossed breed with unimpaired fertility. It is shown that instincts, however originally acquired, are inherited, and are variable; hence they are liable to be improved and specialized by natural selection.

Another great objection to the acceptance of the theory of evolution is the absence of intermediate links among fossil forms, but Darwin shows that the geological record is necessarily very imperfect, and the intermediate links, which do exist among fossil forms,

cannot be accounted for at all on any other hypothesis than that of descent with modification.

The phenomena of geographical distribution are next reviewed, and the impossibility of accounting for them on any other hypothesis than that of evolution insisted upon. Finally, the classification of organisms, the facts of embryology and morphology are reviewed, and all shown to support the theory. The arguments drawn from these various departments of biological science are not essentially different in Darwin's hands from what they were when treated by his predecessors. But since the time of Lamarck, knowledge in these departments had enormously increased, especially in that of embryology. Darwin presented the mass of evidence with a force derived from the breadth and diversity of his knowledge; and it may be said that these arguments give the momentum to his demonstration, while the point of the instrument is furnished by his theory of the method of evolution.

Darwin considered the "Origin of Species" as only a general sketch of this theory and the facts which support it. He originally intended to treat each one of its chapters in greater detail, and so expand it into a volume. This plan was never carried out to the letter; the volumes on the variation of animals and plants under domestication appeared, but the proposed works on variation of organisms in a state of nature, on the struggle for existence and natural selection were never written. Their place was supplied by the succession of works, describing beautiful and elaborate researches into the most diverse classes of biological phenomena, which will ever remain among the classics of the literature of science. Some of these volumes are monuments rather of bibliographical than empirical

inquiry: they all have a close relation to the question of organic evolution, but they do not describe investigations into the process of modification, into the causes of variation or of heredity. They enlarge the boundaries of knowledge, and bring into the field of mental vision new phenomena to be explained by the general theory of biology. Darwin acknowledged that his explanation of organic evolution was not exhaustive, but he devoted himself to the application of the theory he had adopted rather than to the deeper investigation of the premises on which it was based. He had no other choice; he was not a specialist in physiological studies, and even if he had been, the physiology of his day could have given him little guidance. In its present state physiology can say little definite on the fundamental problems of heredity and variation, they remain to be attacked by the physiology of the future.

The two volumes on the "Variation of Animals and Plants under Domestication" were published in 1868. In this case, the original intention to publish a detailed examination of each class of facts embraced in the theory of natural selection was completely carried out; we have a study as exhaustive as the wonderful working power of Darwin could make it, of the process of modification which can be actually traced in the history of cultivated forms of life. In the introduction the whole theory of evolution is restated in outline. The links in the argument are very much what they were before. Man unintentionally exposes his animals and plants to various conditions of life, and variability supervenes, which he cannot prevent or check. The variations are inherited, and by selecting certain variations to propagate from, man is able to modify species in almost any direction he pleases. Similarly, variations

undoubtedly occur in a state of nature, and only those in which the variation is an improvement in relation to the conditions of life, being able to survive, natural selection produces modification and divergence. The first volume is simply and solely a collection of facts; it describes the variations which have occurred in cultivated organisms, and the effects which have been produced by selecting the variations. In the second volume we have a study of the phenomena of inheritance, selection, the causes of variation, and the laws of variation. In the chapter on the causes of variation, it is distinctly explained that "variations of all kinds and degrees are directly or indirectly caused by the conditions of life to which each being, and more especially its ancestors, have been exposed." Use and disuse are shown to be important causes of modification, by increasing or decreasing an organ; the structure of an organ changes when the use of it, that is to say, its function, changes.

In this work, Darwin attempted to penetrate the mystery of the process of heredity by the light of imagination. It contains his hypothesis of pangenesis. Here for once he deserted his usual method of proceeding always from the known to the unknown, from the familiar to the apparently inexplicable. His gemmules have no relation to any known facts concerning the structure or functions of organisms. The reproductive elements are known to be unspecialized cells which are nourished, like the rest of the cells in the organism, by the circulating fluids. We know that the reproductive cells have the property of going through the same series of changes as those exhibited by the parent, and we know that this property must have been impressed upon them in some way or other while in

the body of the parent. But our knowledge is not made clearer by a hypothesis of gemmules which build up the reproductive cells. It is certain that the cells are not built up by composition from smaller units, unless the supposed units are the molecules of the substances by which the reproductive cells are nourished.

The "Fertilization of Orchids" preceded "Animals and Plants under Domestication," although it has less immediate connection with the doctrine of evolution. To the general reader it is perhaps the most attractive of all Darwin's works. The investigation of the way in which cross-fertilization is effected in the orchids might have been carried out without a belief in evolution. The point of view from which Darwin regards the subject is easily indicated. It is a fact, though we do not know exactly why, that cross-fertilization is an advantage to bisexual plants, and every peculiarity in orchidaceous flowers, the simplest as well as the most brizarre and apparently monstrous, has some definite relation to the agencies by which cross-fertilization is effected, that is to say, to the structure and habits of insects, which carry the pollen from one plant to another. Thus in plants originally of the regular form, slight variations arose, by which cross-fertilization was favoured; the offspring of these therefore survived, and were more vigorous than the seedlings of the unmodified flowers, and natural selection thus accumulated the variations until the results we now see were produced. In this work an important principle in the theory of modification is enunciated and illustrated, the principle of change of function, on which so much stress has been laid by Dr. Dohrn, in his inquiries into the probable history of the vertebrate organization :—

"The regular course of events seems to be that a part which

originally served for one purpose, by slow changes becomes adapted for widely different purposes. To give an instance:—In all the Ophreæ, the long and nearly rigid caudicle manifestly serves for the application of the pollen grains to the stigma when the pollinium attached to an insect is transported from flower to flower: and the anther opens widely that the pollinium may be easily withdrawn. But in the Bee Ophrys, the caudicle, by a slight increase in length and decrease in thickness, and by the anther opening a little more widely, becomes specially adapted for the very different purpose of self-fertilization, through the combined aid of the gravity of the pollen and the vibration of the flower."

The lines of inquiry indicated in this work were followed up further some years later in a series of elaborate experiments upon the effects of cross and self-fertilization, which showed that as a matter of actual observation cross-fertilization causes an increased vigour in the offspring of plants in the very first generation. We are still in ignorance of the reason of this; our understanding of the matter remains very much where Darwin left it.

The "Descent of Man" is a special study of the facts which prove that man's morphological relation to the anthropoid apes is not different in kind to that of any genus to another of the same family. In the "Movements and Habits of Climbing Plants," it was shown that all the motions exhibited by plants are specializations of one universally present movement, that of circumnutation, and that each particular motion could thus be produced by natural selection acting on variations of circumnutation. "Different Forms of Flowers" is a contribution to the subject of adaptations for cross-fertilization in plants. In his last work Darwin returned to a geological subject which has no direct connection with the evolution of organic beings, but is a study of one of the most minute and obscure among geological agencies.

Thus the great naturalist's contribution to the general theory of organic evolution ends with the "Animals and Plants under Domestication," and we return to the study of the arguments and conclusions which have played so important a part in the history of modern thought.

It cannot be maintained that those arguments are always formulated with perfect logical consistency. Examined closely, the conception of natural selection comes to this:—An organism usually possesses the same structure as its parents, or to put it in another way, the progeny of organisms of a given species possess the distinguishing characters of that species, But certain individuals of a species may, from some cause or other, before they begin to reproduce, be slightly altered from the exact specific standard, and this alteration is inherited by their descendants to an indefinite number of generations. If this alteration is such that the individuals affected by it are more perfectly adapted to their conditions of life, they will leave more progeny than the unaltered individuals, and thus the alteration in successive generations is present in an increasingly larger number of individuals. To take a specific instance, if a few of the ancestors of the giraffe were endowed from some cause or other with an increased length of neck and were thus enabled to gain a better living and leave more progeny than their brethren, each successive generation would have more individuals with a longer neck. Every time that an increased length of neck was from some cause or other produced, natural selection would tend to diffuse the advantage over the whole species. That is to say, the species, owing to the struggle for existence, would soon come to consist only of the descendants of those

individuals in which some cause had increased the length of the neck. If some cause modified every existing individual of a species exactly to the same extent, natural selection would have absolutely no effect. If some agency caused all the individuals of a species to be less perfectly adapted to their conditions of life, they would soon become extinct, supposing no other conditions of life were open to them. Effects of the kinds thus indicated are the only ones that can follow from natural selection. Natural selection obviously can never be the cause of modification in any given individual. It may, and doubtless does, distribute in a few generations the peculiarities somehow acquired by one or more individuals over a whole species. As this process of picking out modifications goes on in successive generations, any increase in certain individuals of a modification already begun is also distributed over the whole species. This is all that can be meant by the cumulative action of natural selection. But though Darwin sometimes applies to the action of natural selection an analysis as accurate as that attempted above, he frequently attributes to the process effects which are quite beyond its scope.

For example, in discussing compensation and economy of growth, he says :—

"Thus, as I believe, natural selection will tend in the long run to reduce any part of the organization as soon as it becomes through changed habits superfluous, without by any means causing some other part to be largely developed in a corresponding degree. And conversely that natural selection may perfectly well succeed in largely developing an organ without requiring as a necessary compensation the reduction of some adjoining part."

Natural selection can have nothing whatever to do with either the reduction or the development of an

organ; it can only ensure that if the reduction or development occur in one or more individuals, and be an advantage in life, the change shall be present in each generation in a proportionally larger number of individuals. Here is another sentence in which the limitations of the action of natural selection are obscured.

"When a variation is of the slightest use to any being, we cannot tell how much to attribute to the accumulative action of natural selection, and how much to the definite action of the conditions of life. Thus it is well known to furriers that animals of the same species have thicker and better fur the further north they live; but who can tell how much of this difference may be due to the warmest clad individuals having been favoured and preserved during many generations, and how much to the action of the severe climate?"

Natural selection must be always acting when the modification of the fur is different in different individuals. The question is, How is the modification produced? If by the action of the climate, then in what way does exposure to a severe climate cause the fur to become thicker? If we take the word environment as including all the possible causes of modification in a given organism, it is impossible to distinguish, as Darwin attempts to do, between changes due to the environment on the one hand, and changes due to natural selection on the other. It is probable that one of the chief causes of modification is increased or diminished function, and the various changes of function are all summed up in the conception of the struggle for existence.

To Darwin the chief importance of the struggle for existence was that it gave rise to natural selection. To the biologist who believes in function as the chief agent in modification and function as a reaction to

stimulus, the chief importance of the struggle for existence is its relation to stimulus and function.

Natural selection cannot cause an iota of modification in structure. An important distinction may be drawn between general and particular conditions in the modifying environment. It may be profitable to discover for example the difference between the effects on a species of animals, of an increase of average temperature, and of an increased difficulty in procuring food. The increased temperature would in the case of a mammal increase the amount of perspiration, and so cause a more rapid passage of liquids through the tissues, and modify the rate of circulation; these changes would probably result in structural modification. An increased difficulty in procuring food could, as far as natural selection is concerned, do nothing more than reduce the species to the descendants of the better endowed individuals already existing; in relation to the struggle for existence, it would necessitate the more vigorous exercise of certain functions, and this would doubtless result in an improvement of structure. Professor Weismann has recently denied altogether the inheritance of characters and changes acquired in the life of an individual, and attributes modification to the combination in the offspring of the heritable characters of the two parents which unite for reproduction. Even if this were true, natural selection could not be called the cause of modification, it could only ensure the survival of characters due to the interaction of the heritable qualities of the parents.

In the following sentence, Darwin more clearly defines the mode of action of natural selection :—

"In one sense the conditions of life may be said not only to cause variability directly or indirectly, but likewise to include

natural selection; for the conditions determine whether this or that variety shall survive. But when man is the selecting agent, we clearly see that the two elements of change are distinct; variability is in some manner excited, but it is the will of man which accumulates the variations in certain directions: and it is this latter agency which answers to the survival of the fittest under nature."

We have here an instance of the way in which Darwin was enslaved by the spirit he had conjured; he was unable to escape from the anthropomorphism of his own theory. In the case of human selection, not the least modification in an organism can be produced by the process of selection itself. The modifications somehow produced in the animals selected are transmitted to the offspring; but the cause of modification lies elsewhere than in selection; and it is largely due to man's own modification of the environment. In breeding race-horses, training receives at least as much attention as selection; and training is in great measure the application of stimuli to act upon function in the belief that function will modify structure. It is not intended to suggest here that Darwin denied the effect of increased or diminished function; but although he confesses that a complete theory of evolution would include a knowledge of the cause of every variation, he does not devote much attention to the analysis of those causes which he mentions. In considering the process by which Madeira beetles have become wingless, he is inclined to lay far more stress on the fact that the strong-winged individuals in each generation have been blown to sea and destroyed, than on the processes by which the wings of the survivors have been reduced. Undoubtedly in such a case as this, natural selection by the elimination of certain individuals is a most important factor in the rapid

modification of a given species. But the question is, can it be called a cause of modification? All that can be allowed is that the process indicated by the term, the destruction of the unfit, has an important influence on the rate at which the character of a species is altered. Natural selection can never help us to understand the causes of variability or of inheritance. No instance illustrates more forcibly the theory of natural selection than that of the Madeira beetles; but suppose that natural selection in this case were so efficient that all the individuals were blown away, then the species would not be evolved, but removed altogether.

This hypothetical example shows the point at which the preceding criticism is directed. The objections raised apply only to Darwin's discussion of the laws and causes of variation in the "Origin of Species;" from which chapter it would undoubtedly have been better had he omitted natural selection as a modifying agent altogether. No such objection can be made to his exposition of the action of natural selection in causing the extinction of a large number of organic forms. Certain conditions, general or particular do not modify an organism or a species, but destroy it, or as the Americanism epigrammatically expresses the fact, "improve it off the face of the earth." Thus, intermediate forms are removed, and intervals of various degrees between groups of living forms produced.

In the "Animals and Plants under Domestication," the error of confusing the process of selection with the causes of variation is entirely avoided. The later work is more perfectly logical nnd critical than the earlier. It is not to be forgotten that Darwin was engaged in a controversy. The "Origin of Species"

was not merely a study of the causes and history of organic evolution, but an argument to uphold the theory of evolution against that of the immutability of organic forms. It was written to convince a public which the author well knew to hold deep-rooted prejudices against his conclusions, and in his feeling of triumph at posssessing an argument based on what seemed the undeniable effects of human selection, he was led to lay too much stress on the analogous process in nature, and sometimes did not see clearly the limitations of that process. The error has been reproduced in intensified form in the works of some of Darwin's disciples. Now that the controversy has been fought out, biologists are beginning to study more calmly and more successfully the processes of organic modification, instead of merely proclaiming the perfections of the Darwinian system.

Allusion was made above to the anthropomorphic character of Darwin's central conception, and a comparison naturally suggests itself between that conception, and other anthropomorphic views of the universe which have prevailed at successive periods of human history. The earliest and crudest philosophy considers all the conspicuous objects in nature as beings with passions, desires, and wills similar to those of a man, and inquires no further into the origin of these objects. Eventually this stage of thought is replaced by the idea of one supreme Being with vast powers, but still essentially human in character, who created all things out of nothing very much in the condition in which they exist. This idea has been more persistent with regard to living beings than with regard to the not living. The evolution of the solar system from a nebula, and of the earth in

its present condition from a red-hot mass, was generally admitted long before the evolution of the organic world. In place of the idea that species were originally created with their present structure and relations, Darwin set up the conception that by a process of selection in nature similar to that which man exercises on domesticated organisms, the existing complicated system of living beings has been evolved by gradual change from a much simpler original system. The Darwinian argument is not on a very different level from that of the argument from design. The teleologist like Darwin draws a parallel between the effects of human operations and the phenomena of nature. He points to a machine made by human ingenuity, such as a watch: in the watch, every part has its special purpose, which is subservient to the main end, that the hands shall move round the dial at a certain rate. Similarly, when we see the woodpecker with each organ subservient to the main purpose of the animal, to obtain its necessary food supply from insects beneath the bark of trees, we are to infer that some mind much more ingenious than that of man planned and constructed the organization of the woodpecker.

Darwin points to the instances in which man by selection has altered the organization of certain forms till they are more capable of serving his wants or pleasures, and infers that by the selection caused by the survival of the fittest, all organisms have been gradually modified until they have attained their present marvellously perfect adaptation to the conditions under which they live. But our comprehension of the evolution of organic forms will not be complete until it is a constituent part of the conception of universal evolution. That conception itself may be said in one sense to be

anthropomorphic if it is found when completely analysed to rest upon a belief in the persistence of force which is derived from our own consciousness of muscular effort. But this is a general and philosophical anthropomorphism, while Darwin's is particular and empirical. When we have reached a real comprehension of organic evolution, we shall explain the modification of organisms by human cultivation as a particular instance of the general laws of modification and not *vice-versâ*. In an imperfect way we can do this even now. We can see clearly enough that the causes of modification and of inheritance are the same in cultivated as in wild organisms. We can see that the selection of certain individuals by man is, objectively considered, the survival of those individuals which are best adapted to the conditions of life, some of those conditions being human needs and desires.

But before we can attain a complete conception of universal evolution we must discover how to fill up, at least in thought, the chasm between the living and the not living.

The question of the origin of life, the genesis of the first living beings, was never discussed by Darwin. In his first work he did not even allude to the inference from his arguments that man must have descended from some lower form of mammal, and be related by community of descent with the apes, although the inference was immediately made by those who read his work, vehemently combated by some, and as emphatically supported by others. All that Darwin says, is :—

"There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one ; and that whilst this planet has gone on cycling according

to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved."

But as Darwin's spirit of inquiry and speculation could not be stopped by the dogma that species were created at the beginning as they now exist, so subsequent thinkers have speculated as to the origin of the primordial forms of life, notwithstanding that their leader was content to account for the first organisms by the power of the Creator. And here we have a curious anomaly. In other classes of phenomena, and in the transmutation of species, we can point to processes actually going on in the present condition of things as similar to the processes which must have caused the changes of which we find records in former periods of the earth's evolution. Marine fossils of former epochs are now found on hill-tops, and beaches are actually being raised by gradual elevation at the present day above the level of the sea. The phenomena of the glacial period can be illustrated by the effects of the glaciers of Switzerland; the formation of coal can be compared to the modern accumulation of peat, and the origin of many species from one can be seen to be actually going on in the formation of several domestic breeds of pigeons from one. It is thus very tempting to conclude that if living organisms were once formed from unorganized matter, the same process ought to be going on now. And this conclusion has been drawn by more than one writer. Mr. G. H. Lewes, for example, writes:—

"I cannot see the evidence which would warrant the belief that Life originated solely in one microscopic lump of protoplasm on one single point of our earth's surface; on the contrary, it is more probable that from innumerable and separate points of this teeming

earth myriads of protoplasts sprang into existence, whenever and wherever the conditions of the formation of organized substance were present. It is probable that this has been incessantly going on, and that every day new protoplasts appear, struggle for existence, and serve as food for more highly organized rivals; but whether an evolution of the lower forms is or is not still going on, there can be no reluctance on the part of every believer in evolution to admit that when organized substance was first evolved, it was evolved at many points."

Unfortunately for the "probability," every attempt to discover an exception to the general rule *omne vivum e vivo* has hitherto absolutely failed, and it is curious that Lewes should so confidently argue about the probability of the recent origin of organisms from inorganic matter without referring to the celebrated controversy on "spontaneous generation." Up to the present time we have absolutely no analogy to guide us in forming a conception of the origin of living things from inorganic matter, and we have no more reason, scientifically speaking, to talk of the origin of life than of the origin of matter or of energy, however fascinating speculation may be on either point. It is interesting that at first sight it would seem necessary that the first organisms which lived on this planet must have been plants in the physiological sense, must have been able to obtain the energy necessary for their existence by acting on the rays of the sun, and so separating carbon from carbonic acid and forming compounds containing stored potential energy. But this can only be done in the presence of chlorophyll, and a unit of protoplasm possessing chlorophyll is more complex than one without chlorophyll. To get over the difficulty of the earliest living thing on this view, not being the simplest possible, Professor Lankester suggests that the first evolved forms were animals,

and were produced only after a long process of evolution of carbon compounds, which produced first not living albuminoids and then living protoplasm which, in the first period of its life, fed on the antecedent stages of its own evolution. But at present we cannot form any conception of the process by which the first living beings could be evolved. Organic compounds have been produced by synthesis, and it is possible that in the surroundings where life first began albuminoids may have been produced from combinations of the elements. But no synthesis has ever produced living protoplasm, which was able to continue its life by feeding, and reproduce its kind by sub-division or gemmation. The protoplasm of the protozoan, which exhibits no other reproduction but total division, is immortal, although the ultimate elements of which it is composed are continually giving place to others. In compound organisms, although the individual dies, it is derived from a cell which has had through the ages a continuous life of whose beginning we can form no idea. The philosopher who attempts to trace the evolution of the solar system downwards from a diffused nebula, and the naturalist who traces back the history of organic evolution to the simplest forms of living beings, are both finally stopped by the impenetrable mystery of the origin of life. We can form no hypothesis of the beginning of life because we have at present reached no ultimate comprehension of the nature of living processes.

"Flower in the crannied wall,
I pluck you out of the crannies,
Hold you here, root and all in my hand.
Little flower—but if I could understand
What you are, root and all, and all in all,
I should know what God and man is."

J. T. CUNNINGHAM.

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